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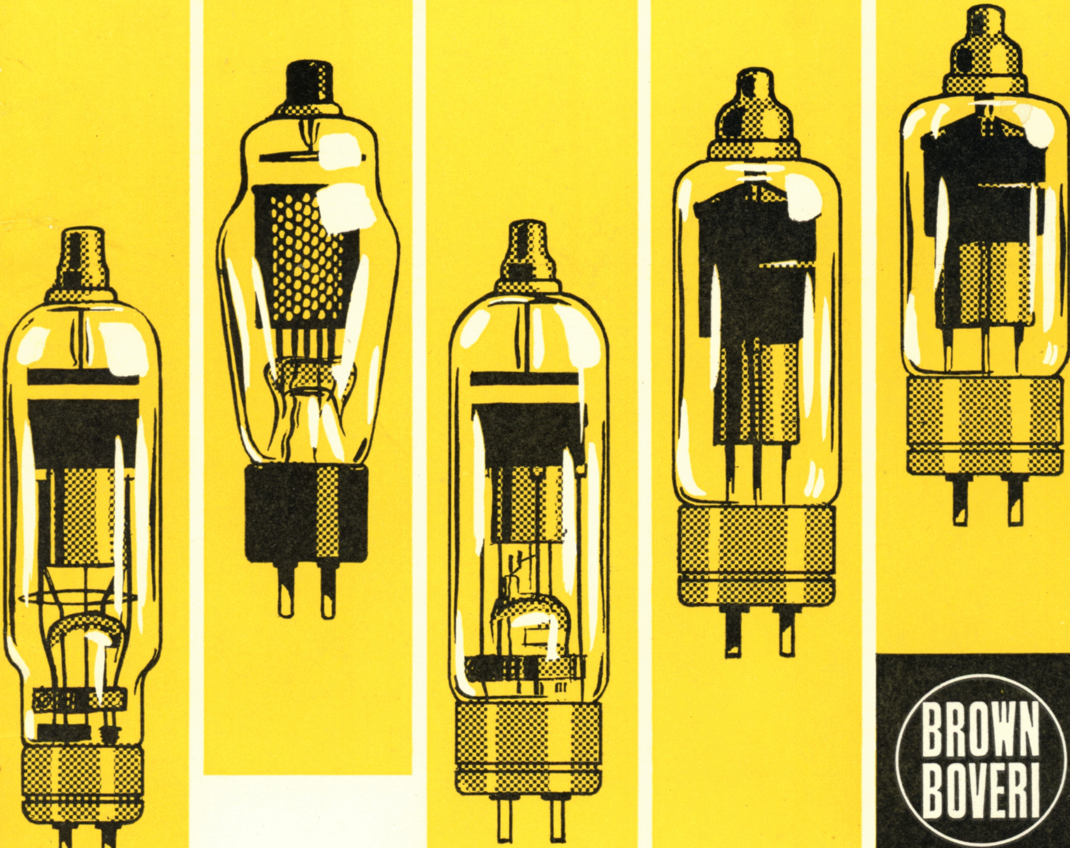
# Industrial Thyratrons for all control applications



BROWN BOVERI

# Brown Boveri Industrial Thyratrons

The extraordinary progress recently made in electronics is allied to that of the gas-filled rectifier tube, with or without control grid. The gas-filled triode – so-called thyratron – has many applications in the improvement of methods of manufacture in many branches of industry.

Thus it is ideally suited to the continuous control of rolling mills, winding machinery in the textile and wire forming industries, elevator control gear, conveyor systems, sequence control gear for machine tools, welders, timers and for special lighting problems.

The high efficiency, simple construction and instantaneous switching action of the thyratron lead to many important advantages. The extraordinarily small control power required enables very complicated regulation problems to be solved in a sure and simple manner, with the expenditure of only a trifling amount of power. Such electronic installations not only result in a better quality product, but also nearly always in a lowering of the price.

The long experience of Brown Boveri in all power engineering fields and in the manufacture of electronic tubes ensures a first-quality construction satisfying all practical requirements. Moreover, use of these tubes in the Company's equipment has increased their experience both from the point of view of construction and in choice of the requisite valve type.

The dimensions and general characteristics of Brown Boveri tubes conform with the international RMA standards.

A life of more than 10000 hours may be obtained from these tubes if the operating instructions are followed. The most important conditions of the latter are as follows:

- The filament voltage must be maintained within ±5% of the rated value (oxide cathode); underheating at full load should be avoided; on the other hand, considerable overheating reduces the tube life.
- Allow the full specified preheating time to elapse before putting the tube on load.
- Do not exceed the given rated limiting values (maximum) of the
  - Inverse voltage (risk of back-fire with consequent damage to the cathode).
  - Peak anode current (to prevent overloading of the cathode).
  - Average anode current (to prevent overheating of the tube).

### Principal Advantages of the Thyratrons with Combined Gas and Mercury Filling

- May be put into operation at very low ambient temperatures.
- Short preheating time; only necessary to bring the cathode (of rugged construction) to operating temperature.
- Preheating time independent of ambient temperature.
- Any desired operating position.
- No spattering and smearing of mercury drops in the upper portion of the tube, improved appearance (clear glass bulb).
- High admissible peak anode currents.

Table I

**The Essential Data of the Brown Boveri Industrial Thyratrons**

| Tube types | | TQ 2 | TQ 1/2 | TQ 2/3 | TX 2/3 | TQ 2/6 | TX 2/6 | TQ 2/12 | 4) TQ 2/25 |
|---|---|---|---|---|---|---|---|---|---|
| Filament voltage*) ....... (±5%) | V | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 5 |
| Filament current, approx. ..... | A | 7 | 7 | 12 | 12 | 22 | 22 | 33 | 36 |
| Minimum preheating time ..... | s | 30[1]) | 30[2]) | 30[2]) | 30[2]) | 30[2]) | 30[2]) | 120[2]) | 300[2]) |
| Filling ........................ | | Hg | Hg+A | Hg+A | Xe | Hg+A | Xe | Hg+A | Hg+A |
| Ambient temperature range ... | °C | +15...+50 | −40...+70 | −40...+70 | −55...+70 | −40...+70 | −55...+70 | −40...+70 | −40...+70 |
| Ionization time, approx. ...... | μs | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Deionization time, approx. ... | μs | 1000 | 1000 | 1000 | 40 | 1000 | 40 | 1000 | 1000 |
| Maximum operating frequency | c/s | 150 | 150 | 150 | 400[3]) | 150 | 400[3]) | 150 | 150 |
| Capacitance: Grid-anode .... | pF | 1.8 | 1.8 | 2.5 | 1 | 3.5 | 1 | 4.5 | 5.4 |
| Grid-cathode... | pF | 5 | 5 | 16 | 50 | 22 | 50 | 25 | 11 |
| Arc voltage drop, approx. .... | V | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Max. admissible peak inverse anode voltage .............. | V | 2500 | 2000 | 2000 | 1500 | 2000 | 1500 | 2000 | 2000 |
| Max. admissible average d.c. anode current Ia............ | A | 1 | 1.6 | 3.2 | 3.2 | 6.4 | 6.4 | 12.5 | 25 |
| Max. allowable peak anode current ($f \geqq 25$ c/s) Iap ...... | A | 4 | 20 | 40 | 40 | 80 | 80 | 150 | 300 |
| Surge current (of max. 0.1 s)**$\hat{I}$ | A | 25 | 120 | 500 | 560 | 1000 | 1120 | 1500 | 3000 |
| Max. mean grid current Ig..... | A | 0.01 | 0.1 | 0.25 | 0.2 | 0.25 | 0.2 | 0.5 | 1.0 |
| Max. allowable negative grid voltage: before conduction . | V | −500 | −500 | −500 | −250 | −1000 | −250 | −1000 | −1000 |
| during conduction . | V | −10 | −10 | −10 | −10 | −10 | −10 | −10 | −10 |
| a) Averaging time (Ia) ........ | s | 15 | 15 | 15 | 15 | 15 | 15 | 30 | 30 |
| b) Averaging time (Ig) ........ | s | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| Net weight .................... | g | 70 | 70 | 230 | 250 | 380 | 280 | 790 | 1665 |
| Shipping weight .............. | g | 260 | 260 | 1000 | 1400 | 1500 | 1400 | 3600 | 8500 |
| Anode connector ............. | | HF 506 709 P1<br>NB 863 820 P3 | HF 506 709 P1<br>NB 863 820 P3 | HF 506 709 P1<br>NB 863 820 P3 | HF 506 709 P1<br>NB 863 820 P3 | NB 400 202 P1 | HF 506 709 P1<br>NB 863 820 P3 | HK 400 913 P1<br>NB 400 202 P1 | HK 400 913 P1<br>NB 400 202 P1 |
| Socket ......................... | | HF 402 587 P3<br>HF 402 587 P4 | HF 402 587 P3<br>HF 402 587 P4 | HK 400 927 P1<br>NB 861 730 P2 | HK 400 927 P1<br>NB 861 730 P2 | HK 400 927 P1<br>NB 861 730 P2 | HK 400 927 P1<br>NB 861 730 P2 | – | – |
| Base.......................RETMA | | A4–10 | A4–10 | A4–18 | A4–18 | A4–18 | A4–18 | – | – |

*) Cathode directly heated; except the TQ 2/25 which is indirectly heated.

**) The complete rectifier circuit must be designed so that its total resistance limits accidental surges to the above indicated value. This value is not a repetitive rating, it is merely given to form a basis for equipment design.

1) Ratings referring only to the cathode heating time.

2) Independent of ambient temperature.

3) Operating ratings ($I_a$) for higher frequencies upon request.

4) At development stage (1. 8. 56).

The power required is a function of the number of tubes used and of their rating. The following table gives the maximum direct-current power requirements for various tube combinations:

Table II

| Circuit | Half-wave single-phase (1 tube) | | Full-wave single-phase (2 tubes) | | Half-wave three-phase (3 tubes) | | Half-wave four-phase (4 tubes) | | Series three-phase (Graetz) (6 tubes) | | Three-phase, double star with smoothing choke (6 tubes) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Valve type | $U_m$ V | $P_o$ kW | $U_m$ V | $P_o$ kW | $U_m$ V | $P_o$ kW | $U_m$ V | $P_o$ kW | $U_m$ V | $P_o$ kW | $U_m$ V | $P_o$ kW |
| TQ 2 | 800 | 1.6 | 1600 | 3.2 | 1180 | 3.5 | 1130 | 4.5 | 2360 | 7 | 1180 | 7 |
| TQ 1/2 | 640 | 2 | 1280 | 4 | 950 | 4.5 | 900 | 5.8 | 1900 | 9 | 950 | 9 |
| TQ 2/3 | 640 | 4 | 1280 | 8 | 950 | 9 | 900 | 11.5 | 1900 | 18 | 950 | 18 |
| TX 2/3 | 480 | 3 | 960 | 6 | 710 | 6.8 | 670 | 8.7 | 1420 | 13.6 | 710 | 13.6 |
| TQ 2/6 | 640 | 8 | 1280 | 16 | 950 | 18 | 900 | 23 | 1900 | 36 | 950 | 36 |
| TX 2/6 | 480 | 6 | 960 | 12 | 710 | 13.5 | 670 | 17.4 | 1420 | 27 | 710 | 27 |
| TQ2/12 | 640 | 16 | 1280 | 32 | 950 | 36 | 900 | 46 | 1900 | 72 | 950 | 72 |
| TQ2/25 | 640 | 32 | 1280 | 64 | 950 | 72 | 900 | 92 | 1900 | 144 | 950 | 144 |

$U_m$ = maximum attainable d.c. voltage at the rectifier output terminals, in volts
$P_o$ = maximum attainable d.c. power, in kW

Apart from being employed in Brown Boveri RF industrial generators, thyratrons are also used in the Company's electronic motor control gear (Thytron), ignition control of welders and equipment for regulating the luminous intensity of sources of illumination (Thyralux)–By means of the latter the luminous intensity of fluorescent tubes may be progressively and continuously varied.

## Principal Features of Pure Gas, and Combined Filling Thyratrons

While the tube types TQ 1/2...TQ 2/25 are filled with a combination of mercury and argon, the types TX... contain only pure gas (Xe).

**The Combined Gas and Mercury Filling** with which all our medium voltage thyratrons are provided results in the following operating advantages: Shortened pre-heating time, since merely the cathode has to be brought to the operating temperature. – Pre-heating time independent of room temperature. – Possibility of putting into operation at low ambient temperatures (down to –40 °C): Use of the gas filling results in higher internal resistance whereby the tube reaches its operating temperature very quickly, at the same time heating the mercury vapour and allowing the tube to function in a short time. – The inert gas filling is not cleaned-up as is the case with pure gas filled tubes, since the gas is only operated during the short pre-heating time and at lower ambient temperatures. — The same high value of inverse voltage (2000 V) as with normal pure mercury filled medium voltage Thyratrons, due to an accurately chosen amount of Argon filling. Other similar types of tubes with mixed filling can usually only withstand lower inverse voltages. — Operation is possible in any position, as the mercury is obtained from a small "Hg-pill". This is a very important feature of these tubes. This method avoids an excessive amount of mercury which would cause spattering of droplets on the upper part of the glass bulb. The bulb remains clear, and the danger of back-fire is reduced. Experience gained with these tubes under various severe operating conditions has benn very satisfactory.

Tubes with **pure gas filling** are to be preferred for all applications where the tubes are operated continuously at very low temperatures, and where the characteristics have to remain unchanged over a wide range of ambient temperature. On the other hand, mercury vapour-filled tubes when pulse operated, compensate this disadvantage. As Xenon-filled tubes are operated with a lower internal pressure, the anode inverse voltage is limited to 1500 V only. They can be operated in any desired position. To prevent these tubes from rapid gas clean-up, care must be taken to operate them within the rated limits of anode voltage, anode current and commutation factor. Particularly, attention should be paid when operating the tubes in polyphase rectifier circuit connection with inductive load.

## Main Advantages of Brown Boveri Thyratrons

Fig. 1 – 21

- Extremely reliable and economical in service
- Rugged construction
- High efficiency
- Long life expectancy
- Low initial cost
- Interchangeable with a great number of international standard types, as shown in the following table:

**TQ 2 replaces:**

| | | |
|---|---|---|
| 976 | ASG 5017 | PL 17 |
| 1701 | CE 309 | TH 6011 |
| 4261 | FG 17 | WL 5557/17 |
| 5557 | NL 715 | WT 272 |

**TQ 1/2 replaces:**

| | |
|---|---|
| 3 C 23 | |
| ASG 5023 | FG 81 A |
| CE 311 | TH 6230 |

**TQ 2/3 (TX 2/3) replaces:**

| | |
|---|---|
| 5544 | C 3 J |
| ASG 5044 A | CV 2210 |
| BT 91 | XRI 3200 |

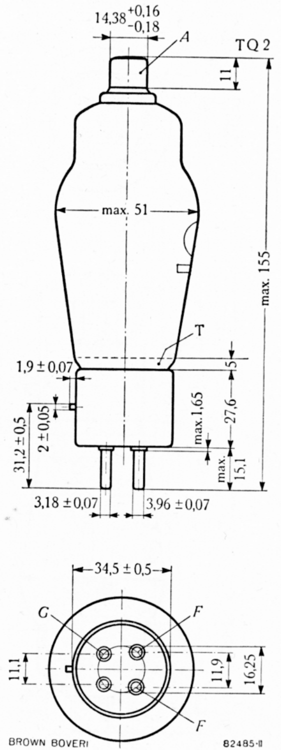
**TQ 2/6 (TX 2/6) replaces:**

| | | |
|---|---|---|
| 5545 | CV 2215 | TGZ 106 |
| 3 G 501 | C 6 J | TH 6220 |
| ASG 5045 A | | XRI 6400 |

## Replacement of Tubes Manufactured by Other Firms

To enable us to advise you on this subject we would require, in all cases, the following information:

1) Type of tube and manufacturer's name.
2) Type of rectifier circuit (if possible with circuit diagram).
3) Desired maximum d. c. voltage $U_m$ and the d. c. current $I_m$ at the rectifier output.
4) When a filter is used, the value of its inductance and capacitance (choke input is recommended).
5) Whether the secondary winding of the heater transformer is provided with tappings.

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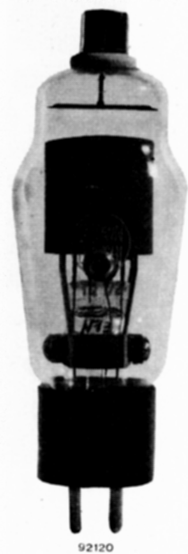
TQ 2

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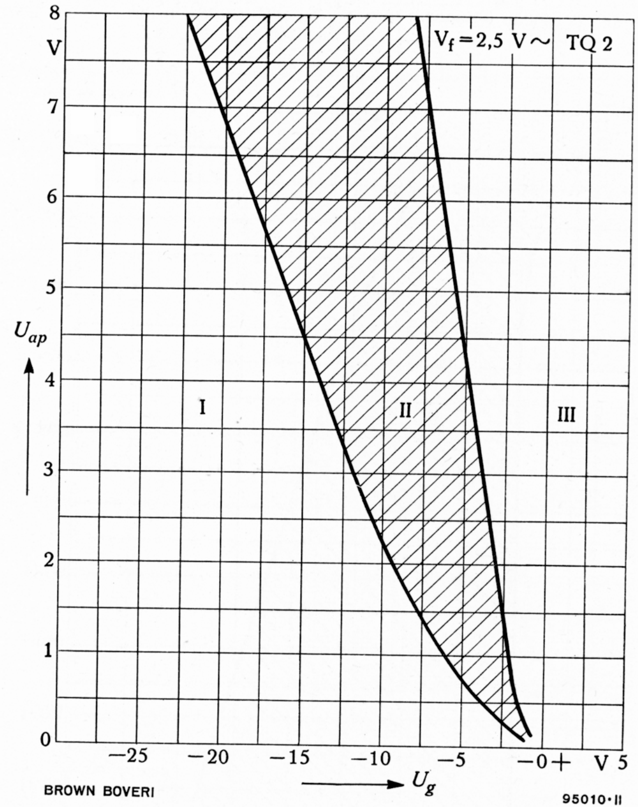


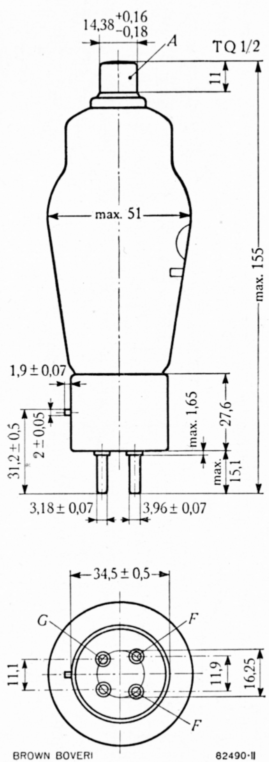

1 Dimensional outline drawing    2 Photograph    3 Control characteristic of the mercury-vapour-filled thyratron type TQ 2

$U_{ap}$ = Peak anode voltage    $U_g$ = Grid voltage    $A$ = Anode    $G$ = Grid    $FF$ = Heater (filament voltage)

$T$ = Zone of condensed mercury, where Hg-temperature is to be measured

I = Non-conducting zone    II = Critical range (includes initial and life variations of individual tubes)    III = Conducting zone

# TQ 1/2

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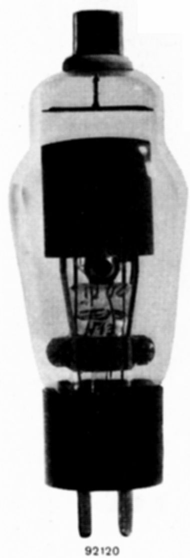


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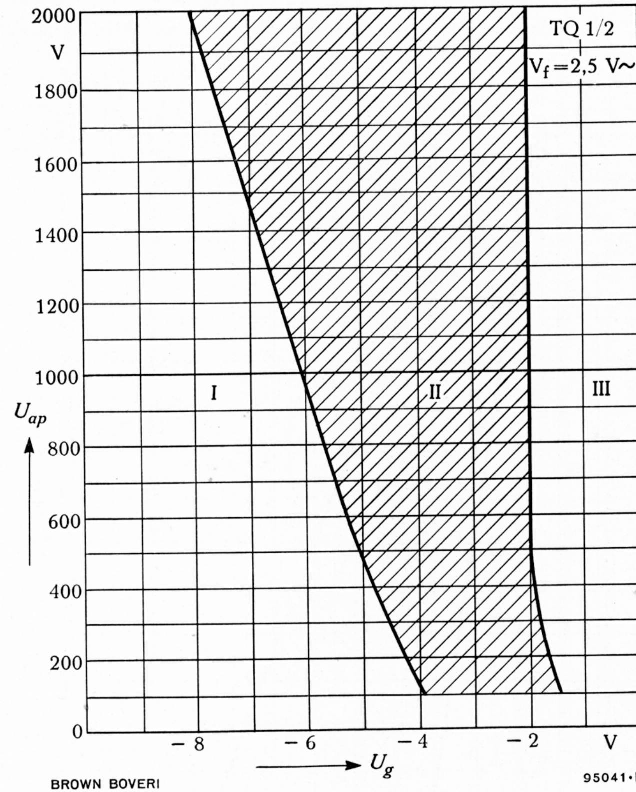


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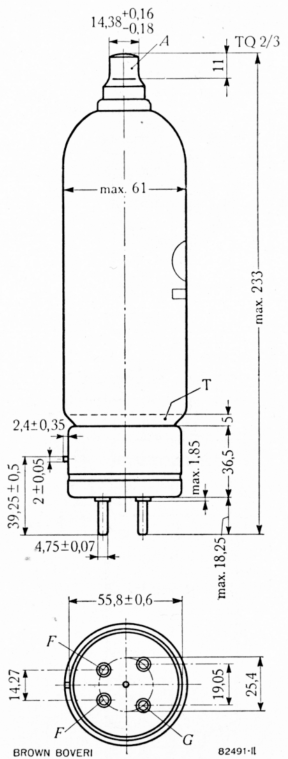
4 Dimensional outline drawing

5 Photograph

6 Control characteristic of the thyratron type TQ 1/2 with combined filling

# TQ 2/3

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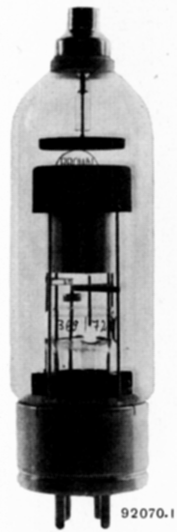


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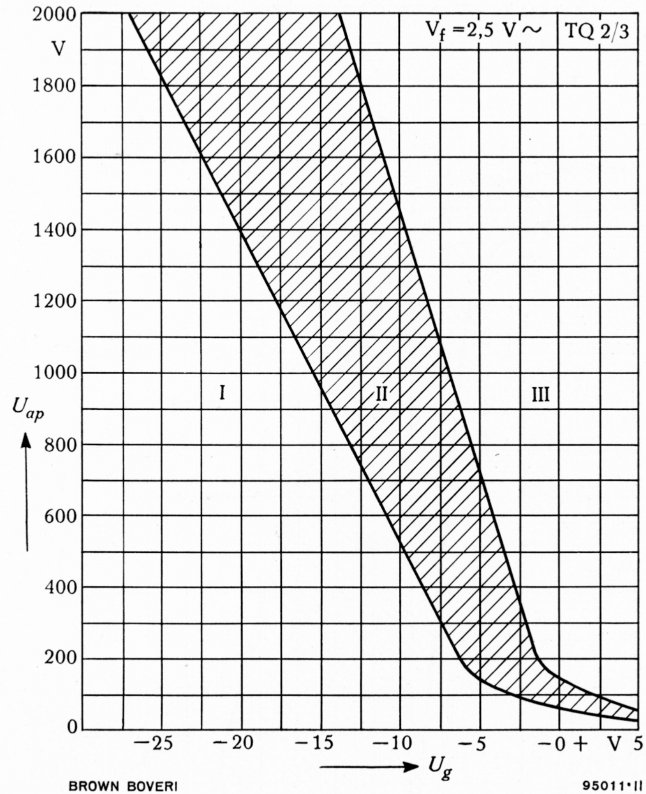


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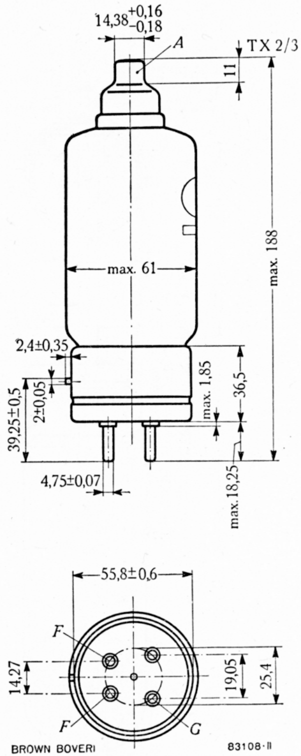
7 Dimensional outline drawing  8 Photograph  9 Control characteristic of the thyratron type TQ 2/3 with combined filling

# TX 2/3

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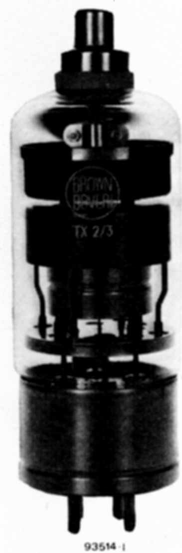


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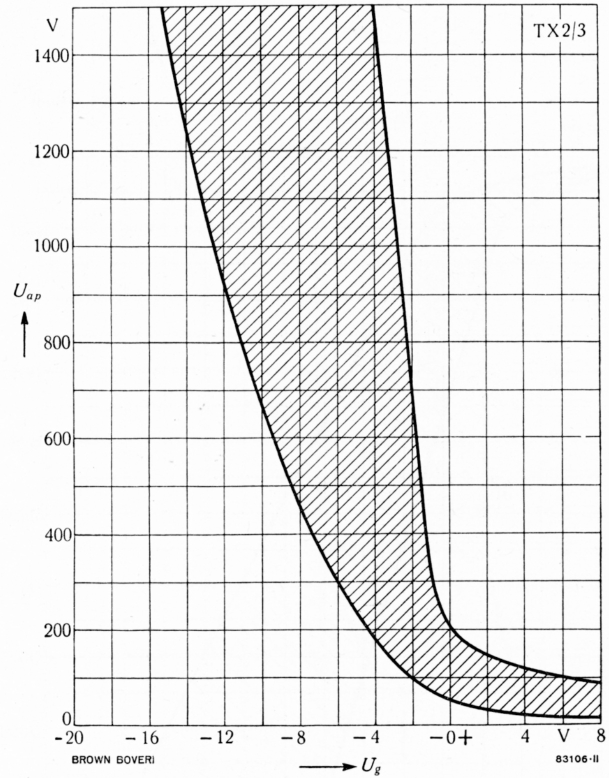


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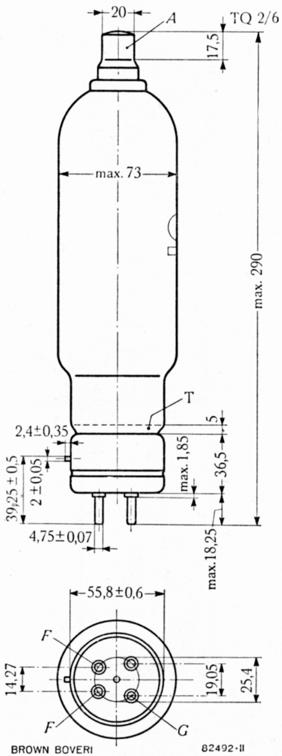
10 Dimensional outline drawing 11 Photograph 12 Control characteristic of the inert-gas-filled thyratron type TX 2/3

# TQ 2/6

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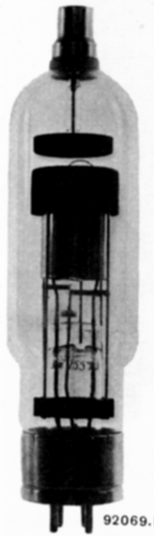


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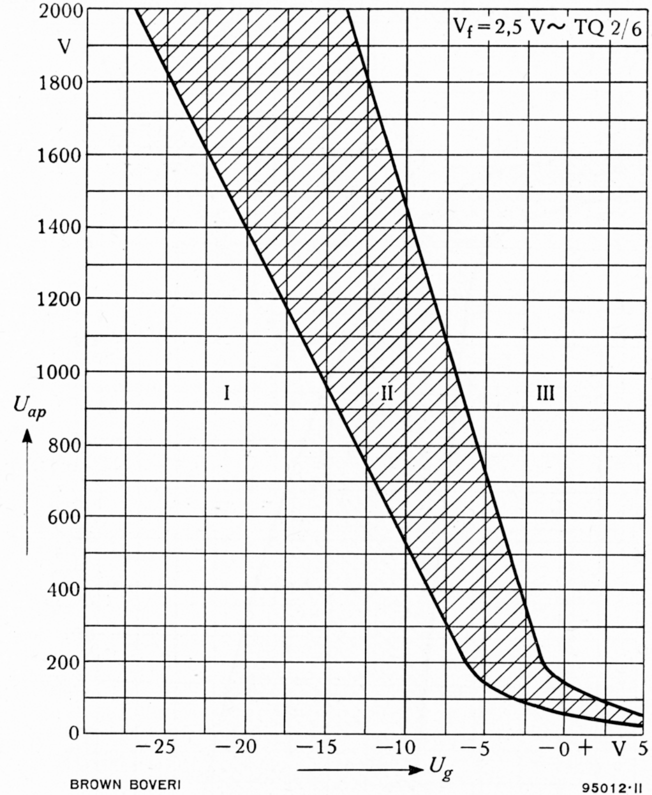


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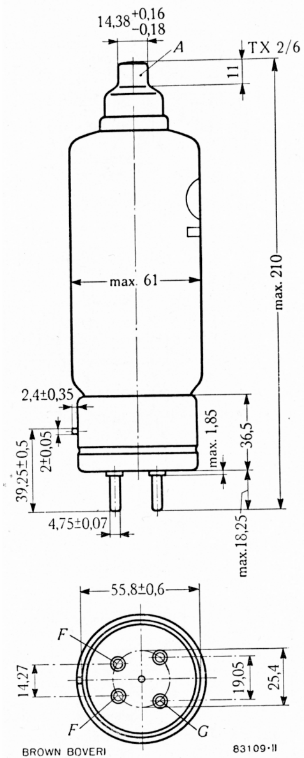
13 Dimensional outline drawing 14 Photograph 15 Control characteristic of the thyratron type TQ 2/6 with combined filling

# TX 2/6

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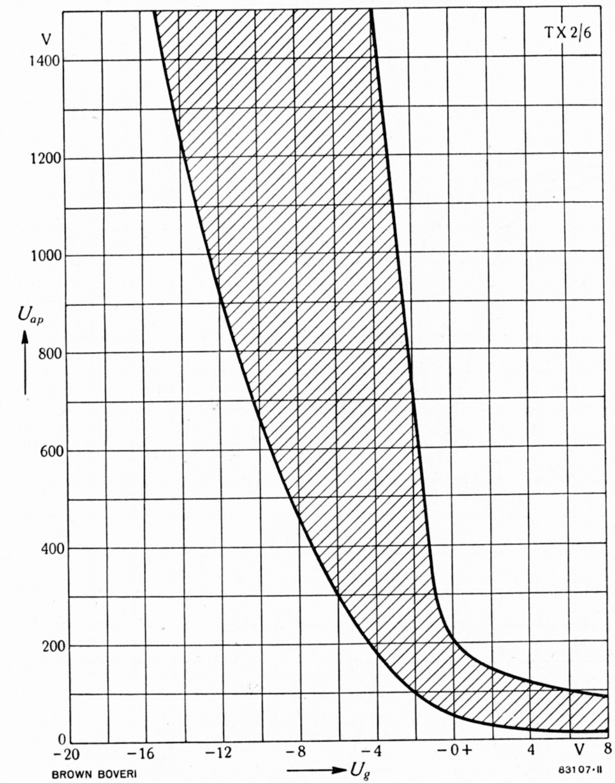


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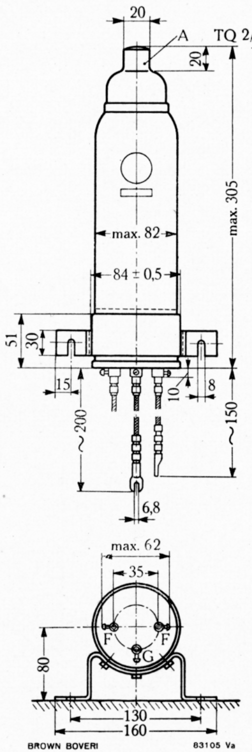
16 Dimensional outline drawing

17 Photograph

18 Control characteristic of the inert-gas-filled thyratron type TX 2/6

## TQ 2/12

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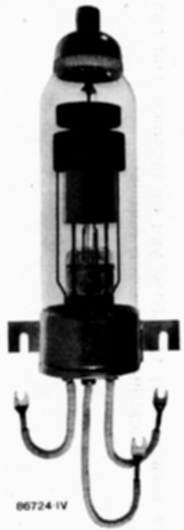


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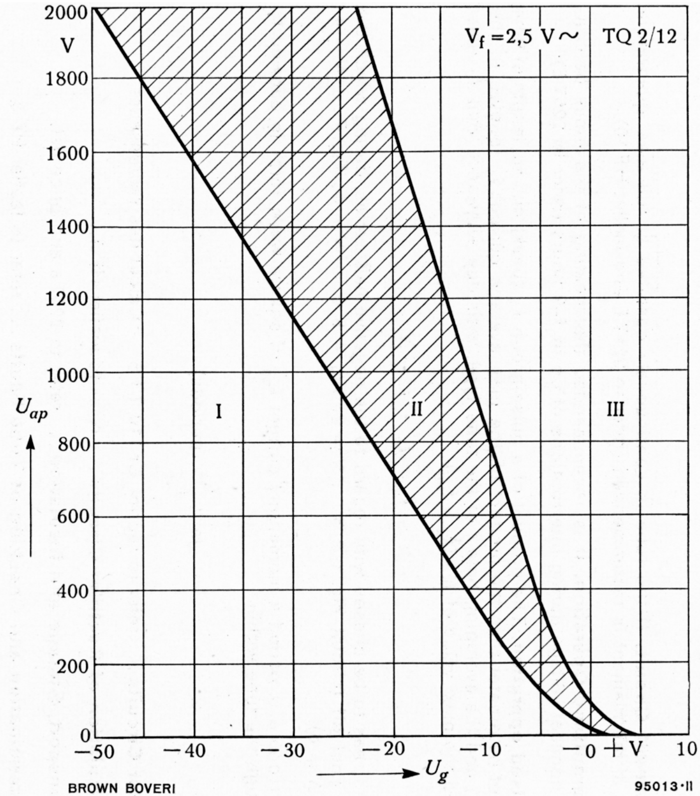


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19 Dimensional outline drawing 20 Photograph 21 Control characteristic of the thyratron type TQ 2/12 with combined filling

1) **Filament Circuit.** If the tube is continuously operated at full load, quadrature operation of the filament is recommended (refer to 2257 E and leaflet HF 10).

2) **Intermittend Operation.** It is recommended that heating of the tubes be continued at nominal voltage during interruptions of up to 1–2 hours (refer to 2257 E).

3) **Pulsed operation.** The product of a pulse-group $\hat{I}_a$ (peak) and its length of time $\Delta t$ may not be greater than the product of the max. average current $I_a$ (quoted in the tube data) and the averaging time $t$ of the tube type, with due allowance that $\hat{I}_a$ must not exceed the max. value of $I_{ap}$ ($\hat{I}_a \leq I_{ap}$).

$$\Delta t \cdot \hat{I}_a = I_a \cdot t \cdot N$$

where $N$... has to be chosen with regard to the negative half cycles, during which the tube can cool off (circuit Fig. 1, 2, 3 ... $N = 2$; Fig. 4, 5, 6 ... $N = 3$; Fig. 7 ... $N = 4$; Fig. 8 ... $N = 6$).

Within one a. c. period a momentary current $I_{ap}$ of square wave form is allowed to flow through the tube within

$$\Delta t = \frac{I_a}{I_{ap}} \text{ (periods)}$$

4) **Filter Circuits** ... refer to reprint Gr 110 7/FS — Calcul des redresseurs.

5) **Calculation of Rectifier Circuits** ... refer to leaflet HF 7.

6) **Transport, Storage and Insulation** ... refer to 2257 a and price list.

7) **Determination and Checking of Tube Faults** ... refer to leaflet HF 5.

8) **Tube Characteristics** ... refer to reprint E. R. H 12/1955 (R. Hübner) available in German only.

● We are always ready to advise you on technical and operational problems, and to send you technical literature upon request.

BROWN, BOVERI & CO., LTD., BADEN SWITZERLAND

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